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PHYSICS AND MATHEMATICS

No. 61

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USSR REPORT

PHYSICS AND MATHEMATICS

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LASERS AND MASERS

SYNTHETIC 'RUBY' DEVELOPED FOR LASER RESEARCH

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 19 Dec 79 p 2

[Article by G. Alova: "The Heart of a Laser"]

[Text] In the Precious Stones Section of the State Historical Museum there is kept under glass a red rose of such beauty that it is difficult to tear one's eyes away from it. It looks as if it is alive, although it is made of that stone that we normally name "ruby." The synthetic version of this stone may not be as valuable to jewelers, but in the Museum of the History of Science and Technology it would surely occupy one of the most honored places, for it was in just such a synthetic ruby crystal that the famous laser beam was born.

Thus, to the ruby belongs the glory of being the best material for solid-state lasers. Only specialists knew that it owes this glory not so much to its own structure as to the admixtures of chromium ions. They are what converted a colorless corundum crystal into a blood-red ruby. After being "pumped" with energy, they emit the unique laser beam. They are also related to one of the main shortcomings of the ruby laser: it creates pulsed radiation, in the form of short bursts.

"Even today no one intends to write the ruby off," says the person I am interviewing, laboratory supervisor and Doctor of Physical and Mathematical Sciences V. Osiko, "but the palm of its superiority soon passed to another manmade material -- the garnet. In the garnet, neodymium replaces chromium as the working admixture. Because of this, lasers have acquired the desired property -- they have become generators of continuous emissions. And everything would have been all right if garnet were not so expensive. For example, in the United States a laser rod made of garnet that measures 6 by 75 millimeters costs about 1,000 dollars. . ."

Since the heart of the matter is the neodymium ions, why not try to introduce them into some other cheaper crystal? Researchers in many laboratories throughout the world have asked themselves this question. This includes the workers in the Solid-State Physics Laboratory of the USSR Academy of Sciences' Institute of Physics imeni P.N. Lebedev. When it was discovered that such crystals do not exist "in nature" and it is necessary to synthesize them specially, the scientists' thoughts reached even further: why is it even necessary to use a crystal? Why not some well known optical material, such as glass?

Audacity? If one looks "behind the scenes" of the problem, that is the only word that is appropriate. In the garnet laser, the crystal itself serves only as a matrix, or rigid framework, that holds the neodymium ions at certain points. That is the key: at certain points. If the ions were closer together, they would simply share the accumulated energy with their neighbors and convert it to heat. There would be no emissions.

From this viewpoint, amorphous glass was a material that was known to be unsuitable. There is no crystal lattice in it. Therefore, the neodymium ions could be arranged any which way, including close to each other. Why, then, did the scientists choose glass?

"To some extent this decision was forced on us," answers Vyacheslav Vasil'yevich. "Actually, we had to create lasers for optical electronics. In other er words, they had to be as small as possible. . ."

Modern computers operate at fantastic speeds. However, scientists think that the operating speed could be much higher if the "slow" electronic impulses in information exchange devices were placed with a high-speed light beam. Miniature lasers with a high energy output are also needed for these devices. How are they to be created?

One of the possible solutions to the problem is to introduce as many neodymium ions as possible into the laser rod. However, the very structure of crystals rebels against this: in them, as in a metropolitan hotel, there are always very few free places that are "reserved" for admixtures. Here the advantage of glass is revealed: it is ready to accept a practically unlimited number of "lodgers" in the form of neodymium ions. However, in order that they not interact and damp the emissions, it was necessary to isolate them from each other in some way. In order to do this, it is necessary to make glass resemble a crystal to some degree.

So the physicists cooked glass, adding different components to it. These components included phosphoric anhydride. Experiment followed experiment, but no one could catch the firebird of success. Perhaps it was only the thought that a glass-phosphate laser rod would be ten times cheaper than a garnet one that compelled the scientists to continue their search. Their patience and persistence were generously repaid: when an excessive amount of phosphoric anhydride was introduced into the glass, its structure underwent substantial changes.

"Now a unique type of partition consisting of phosphorus-oxygen chains appeared in the glass, and these partitions reliably isolated the neodymium ions from each other," relates a scientist. "Moreover, the chromium that had also been added to the glass began to act like a 'neighbor' and supplied additional energy to the ions. And so, miniature lasers with glass cores, destined for use in integral optics and communication systems, were finally developed! At the same time, their efficiency was triple that of garnet lasers!"

At first the scientists thought that the ultraphosphate neodymium glass they had created was suitable only for producing rods for miniature lasers. However, they soon discovered that large castings of this material also compete successfully with garnet. And, summing up the results of this work, Academician A. Prokhorov emphasized that it is opening up new possibilities for both the miniaturization of optical electronic systems and improving the energy parameters of lasers.
[77-11746]

11746
CSO: 1862

MOLECULAR PHYSICS

INITIAL RESEARCH ON ANIONIC GLASS REVIEWED

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 26 Dec 75 p 4

[Article by special correspondent G. Lomanov, "Unexpected in the Usual Run of Things"]

[Text] They entered the room excited, smiling, somewhat aloof: their discovery had just been recorded at a board session of the USSR State Committee on Inventions. In their thoughts they were both still there, in the hall. Yevstrop'yev rolled the charts into a tight cylinder; Petrovskiy put the samples into a briefcase. For a moment, he held a suspended square of massive, perfectly polished glass, then he handed it to me:

"Take it; add it to your collection."

An almost identical prism has been lying on my desk for a year and a half--a rememberance of a meeting at the Flight Control Center. At that time, the crew of the "Salyut-6" had been the first to initiate in-orbit experiments on obtaining optical glass under weightless conditions. Guriy Timofeyevich Petrovskiy, member-correspondent of the USSR Academy of Sciences, was their science instructor. Somehow, while relating the work of the cosmonauts, he got carried away. We listened to a genuine ode in honor of the glass--a material that was, it seemed, very commonplace.

Since that time, I have kept this souvenir prism. It didn't let me forget an old truth--the only interesting person is one who is enthusiastic about his work.

And now here is another prism. Maybe the play of light on its crystal faces will someday remind me--discoveries only come to enthusiastic people.

We have become accustomed to the classical scheme: a discovery is a flash, a fortuitous instant of illumination. Why, of course, we remember from school the exclamation of Archimedes, "Eureka!."

"Well, no," smiles Konstantin Konstantinovich Yevstrop'yev. "That only happens in the movies: you sit, think it over and, hurray, it dawns on you!

In order to do something worthwhile in science, you need years and years of work. At least we had the years."

Twenty years ago, the young candidate of sciences, G. T. Petrovskiy, went to work at the GOI--The State Optical Institute imeni S. I. Vavilov. He studied fluoride glasses. In contrast to ordinary glass, it is derived not from silica, but from beryllium fluoride. It must be noted that a few people were working with it--enthusiasts, primarily. Fluorides are generally toxic, and beryllium fluoride is particularly so. In the performance of his duties, G. T. Petrovskiy had to investigate the optical characteristics of these glasses and he, in addition to the program, studied also their electrical conductivity. He then noticed an entirely unexpected mechanism.

We must here digress slightly. Glass is essentially an insulator. However, although very weakly, it still does conduct an electric current. As early as the beginning of the century, it had been established that all processes of transmitting electricity through glass entailed the displacement within the glass of positive metallic ions--cations. The scientists of the Physical-Technical Institute imeni A. F. Ioffe then explained: within the glass there is another type of "transport" for electrical charges--electrons. That is all. Other mechanisms were simply considered to be impossible.

Why? There are also, you see, anions in glass--negatively charged atoms of oxygen, fluorine and chlorine. The fact of the matter is that anions are gigantic in comparison with the cations in metal (experts will forgive me for taking these liberties!). The anions are so much larger that one might boldly say that it is the anions that form the "framework" of a substance. You can think that they travel through the mass of glass, carrying the electrical charges with them. It does not matter how you put it, whether you say the train left or the station did. In 1961, G. T. Petrovskiy, together with his colleagues, published a paper in which they put forth the supposition that it is the anions that travel in the glass.

A week ago, when the discovery was recorded, this paper had been mentioned as a priority. It had been, however, a very long way from there to "Eureka!."

The supposition was essentially a hypothesis. What was it in reality? Guriy Timofeyevich decided to test it and turned to K. K. Yevstrop'yev.

"We were friends, both in science and in general," recalls Konstantin Konstantinovich.

I liked that well-turned phrase. Not confederates, not colleagues, but friends in science. K. K. Yevstrop'yev was one of the authors of the method which allows us to determine the nature of the particles that carry the electrical current. Together they studied G. T. Petrovskiy's glasses and the supposition proved to be correct. They published a paper which figured as a second priority in the recording of the discovery. At the time, however, neither of them thought that they had made a discovery.

The normal work went on, and in a few years the scientists studied about twenty various vitreous systems. They also contemplated curious methods of practical application of the phenomenon they studied.

Here, for example, is one of the problems. In order to obtain a material with high electrical resistance, they had previously gone about it simply--they took glass with a low concentration of cations. It was quite clear: when the transporting units in the glass are few, it means that it is more difficult for the electrical charges to make their way through the glass. However, the fewer the cations the higher the melting point of the glass and the lower the coefficient of thermal expansion--these parameters are mutually linked. In equipment, it is frequently necessary for glass to bond to metals whose coefficient of thermal expansion varies within very great limits. Sometimes it was difficult to select the necessary pair. Anionic glasses make it possible to control electrical conductivity without changing other parameters. They are not dependent upon the concentration of anions.

The new type of glass is even suited for metallurgy. Now, in order to protect metal, it is covered with a thin layer of glass. The billet is excellently preserved, but if it is struck hard enough just before it is to be worked, the covering crumbles into pieces. The method is well-known, but it is preferable to use anionic glasses-- they behave very effectively compared to an imperfect coating of metal. This is why a jacket "cut" from them protects more effectively.

One of professor K. K. Yevstrop'yev's co-workers was defending his own dissertation. Guriy Timofeyevich listened to those who spoke, and a thought occurred to him more and more persistently--how much had physical chemistry's whole system of opinions about vitreous states changed in these last years. In just this narrow field, things had changed fundamentally. In essence, a discovery had been made. He told this to his coauthor.

"Honestly speaking, I regarded it sceptically," recalls K. K. Yevstrop'yev. "It is not easy to say whether it is a discovery. Take those people who have discovered a new element or an elementary particle--they have their synchrophasatron, that sort of thing. And here we are with our pieces of glass. No, this is, of course, a joke. Seriously speaking, we feared the requirement that the discovery introduce fundamental changes in the notions about the surrounding reality. What if our changes are not fundamental?"

They were disturbed by something else, too. This would be the first discovery in the 150-year existence of the Technological Institute imeni Lensovet, where K. K. Yevstrop'yev worked. The first person is always worried. G. T. Petrovskiy had his doubts, too. At the State Optical Institute, on the other hand, several such had already been recorded. One day their claim would appear against this background. Well then, they both had to speak at scientific councils.

"But we are scientists, not some kind of Djigits [quick horsemen]," they laugh. "We didn't wish to become the talk of the town. There are the two men who, they say, tried to discover something, go ask them how it is done."

They received positive replies from dozens of leading institutes, and related their work to colleagues in Tbilisi, Minsk, Moscow and Yerevan. Honsetly speaking, they literally placed themselves under their critics' fire. Finally, the doubts fell away when such famous scientists as Yu. A. Ovchinnikov, N. N. Semënov, N. M. Zhavoronkov and N. M. Emanuel' voted unanimously for them at a section of the presidium of the USSR Academy of Sciences.

Years of labor, years of doubt. How does one fit them into the classic scheme of discovery: you sat, pondered, then cried out,"I found it!" No, it does not happen that way.
[85-9512]

9512
CSO: 1862

APPLICATIONS OF FERROMAGNETIC LIQUIDS DISCUSSED

Moscow PRAVDA in Russian 16 Dec 79 p 3

[Article by V. Gerasimov, PRAVDA special correspondent, Leningrad: "Miracles in a Beaker"]

[Text] The experiment quickly reached its climax. Into a beaker containing a dark, oil liquid, Junior Scientific Worker Nikolay Gribanov dropped a three-kopeck piece. As would be expected because of the laws of physics, it sank. But after a minute -- contrary to those same laws -- it rose to the surface. This was the result of Gribanov's bringing a magnet into contact with the bottom of the beaker.

"That is one of the properties inherent in the liquid that has been poured into the container," he explained. "When acted upon by a magnetic field, it expels 'foreign' bodies."

The next experiment was no less marvelous and simple. Vladimir Shumilov, a staff member in the Department of Colloid Chemistry at the Technological Institute imeni Lensovet, proposed to stir the contents of another beaker with a knife.

At first the knife did not encounter any resistance, but when a magnetic field was brought near the beaker it was as if it had encountered an obstacle. Before our very eyes, the liquid became viscous. As soon as the magnetic field was turned off, the knife again began to clink merrily against the glass.

"The unusual properties of the so-called ferromagnetic liquids can be demonstrated at great length," comments the head of the department, Professor I.S. Lavrov. "Actually, they are prepared on the basis of water, kerosene, oils, mercury and metal melts. Very fine particles of iron, ferrites and other ferromagnetic substances are 'dissolved' in them. If we multiply the possible number of components among themselves and then consider the difference in the 'behavior' of the same liquid when the magnetic field is altered, we obtain a long series of interesting qualities that can be used very profitably in science and technology.

"Let us take, for example," continues the scientist, "the last experiment we saw: the capability of a liquid to change viscosity. Any technologist or machine-tool operator will appreciate such a property. Extremely clever attachments are used in the machining of large, geometrically complex and thin-walled articles. And what could be simpler than to install an ordinary container holding a ferroliquid on a machine tool instead of an expensive piece of equipment? In it, under the influence of a magnetic field, the part is held firmly. When it is necessary to remove the finished article or change its position, just turn off the field."

A group of workers in the department have been occupied in working out the compositions of ferromagnetic liquids, studying their properties and selecting areas for their use for about 15 years. These unusual materials do have one characteristic feature: the solution is attracted and held by the field of a magnet or flows in the direction of a magnetic field. Such constancy of behavior, in combination with the great variety of special features that are characteristic of each type of liquid, makes them quite versatile.

A copper coin floats on kerosene that has iron particles suspended in it. An amusing anomaly, but is it only that? The fact of the matter is that from this "miracle" in the beaker of kerosene there runs a straight and short road to many millions of rubles' worth of savings of assets in the national economy. It has been calculated that a liter of this liquid does not cost more than 1 ruble. It can be produced in unlimited quantities. This is a straightforward reason for using it in processes for enriching useful minerals, so as to extract even from low-grade soil or wastes not one or several basic components, but all of the valuable substances in sequence. The accuracy of the separation of substances by specific weight has actually reached a level where "magnetic" kerosene can errorlessly "tell," for example, one grade of aluminum from another and expel to its surface pieces of metal in sequence.

When planning complicated machines, the designers frequently shake their heads: what is the best way to insure a sealed outlet of a running shaft from the housing of a unit? Although countless variants have been devised, they can all be reduced to a single, commonly known method: the gap is covered with rubber (or some other elastic material) gaskets. They wear out quite rapidly. Under extreme conditions, they prove to be entirely unsuitable. Other ways of sealing must be found and the equipment's design will probably be made more complicated.

"Here, also, a magnetic liquid can be of assistance," says Professor Ye.Ye. Bibik, a work supervisor, as he demonstrates a complex unit on a laboratory bench. "This sealing element for a vacuum pump is capable of serving reliably and for an unlimited length of time. The problem has been solved quite simply: the gap is covered with several drops of a ferroliquid and a magnet, which also serves to hold the solution in place. The successive installation of similar elements insures the sealing of equipment designed for operation under a pressure of hundreds of atmospheres. The movable couplings of any machine -- from chemical equipment to marine propeller shafts -- are sealed reliably. For an axle, it is as if it is swimming in an extremely thin layer of liquid without touching the walls of its supporting structure. A unique bearing that operates with practically no friction is obtained."

Thousands of experiments have been performed in the Department of Colloid Chemistry. Step by step, the horizons for the use of ferromagnetic liquids are being broadened. In the opinion of the scientists, solutions with controllable viscosity can be used as the artificial, smoothly controlled "muscles" of robots instead of the lever and hydraulic designs now in use. They will also serve as an ideal cushion and can replace platforms that carry heavy loads. The possibility of developing systems for noncontact recording of information on ordinary paper has been proven. If recording tape is covered with a thin layer of a ferroliquid, the coded entry becomes visible. Their capability of changing from a state of transparency to complete opaqueness in thousandths of a second makes magnetic liquids suitable for use in optics. Doctors use them to stop the hemorrhaging from extremely small blood vessels during operations and, together with chemists, are searching for the formulas of compounds that in the near future will deliver doses of medicine directly to an ailing organ.

Dispersed ferromagnetic systems have advocates who are specialists and are studying them in Perm' and Stavropol', Riga and Minsk, Khar'kov and Nikolayev. A number of enterprises have laboratories and groups of enthusiasts are actively working in this field. However, their work is uncoordinated. The use of the liquids is also limited: there is simply nowhere to take them.

"The branch institutes and enterprises have written us a whole mountain of letters," says I.S. Lavrov, displaying a thick packet. "Of course, we try to satisfy the requests -- we send someone a liter, someone else 10 liters. But can you do a lot without a production base? The scientific inventory of applied research in our laboratory alone is large enough so that it would take an entire specialized institute to handle it. There is no subordinate unit that could solve the engineering problems entailed in the development of magnetic devices with optimum parameters. Chemists just are not able to do that."

The scientists' concern is completely understandable. Industry's requirements for universal reagents for the enrichment of minerals, and magnetic seals and lubricants in machine building, are growing, although the production technology for manufacturing ferroliquids in sufficient amounts is by no stretch of the imagination opening the way. Organizations in many departments, as is apparent from their correspondence with the Institute, are interested in using magnetic liquids. However, each of them thinks only of its own requirements. There is still no single patron capable of financing and organizing large-scale research and concerning itself with the introduction of the obtained results. Therefore, the marvelous properties of ferromagnetic liquids will not be at the complete disposal of the national economy.

[76-11746]

11746
CSO: 1862

USSR UDC 621.385

INFLUENCE OF ELECTRON BOMBARDMENT ON THE GROWTH OF FILMS OF CERTAIN METALS (Al, Cu, Sb) ON DIELECTRIC SUBSTRATES

Moscow VESTNIK MOSCOVSKOGO UNIVERSITETA SERIYA 3 FIZIKA - ASTRONOMIYA in Russian Vol 20 No 5, Sep/Oct 79 pp 54-62 manuscript received 9 Mar 78

DUBININA, YE. M., YELOVIKOV, S. S., OVSYANITSKIY, A. S., NETISHENSKAYA, G. P., and KIRILENKO, YE. P., Department of Electronics, Moscow State University

[Abstract] A study is made of the problem of the influence of electron bombardment on the growth of films of Al, Cu and Sb on single crystal NaCl (air cleavage) substrates and nonoriented substrates of glass-ceramic and silicon monoxide. The metals selected were used because of their broad application in electronics. The influence of electron bombardment on epitaxial growth of films is studied, as well as the influence of electron bombardment on the properties of Sb and Al films on nonoriented dielectric substrates. The experiments show that electron bombardment before and during formation of films decreases the epitaxial temperature of copper films by about 100°C, aluminum by about 150°C and antimony by about 180°C. Preliminary bombardment of the substrate and bombardment during the early stages of the process of condensation are particularly effective. The Auger spectra of films grown with and without bombardment at a condensation rate of 20 Å/s indicate that there is a smaller quantity of oxygen in the bombarded films. This may be explained by an increase in the supersaturation of Al over the bombarded surface of the film. Figures 5; references 14: 2 Russian, 12 Western.
[70-6508]

USSR

SUPERLUMINAL SOURCE IN A WAVEGUIDE

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR - FIZIKA in Russian Vol 14 No 4, 1979 pp 240-246 manuscript received 27 Apr 79

BEGLOYAN, E. A. and BEKOVA, S. KH., Yerevan Physics Institute, Dagestan Pedagogical Institute

[Abstract] An earlier work suggested a model of a superluminal source in a plane waveguide. However, the earlier work analyzed an idealized waveguide consisting of two parallel ideally conducting plates. The present work suggests a theory of radiation from a superluminal radiator for a regular waveguide of arbitrary cross section. Expressions are derived that can be used to compute the energy flux of transient radiation in a waveguide. The intensity of the Cherenkov radiation lines is proportional to the length of the trajectory of particles in transverse and effective longitudinal movement. Figure 1; references 4 Russian.
[72-6508]

USSR

SUPERSONIC PULSE DISCHARGE OF ARGON FROM A CONICAL NOZZLE

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 49 No 11, Nov 79
pp 2516-2519 manuscript received 18 Jun 79

DOBRYNIN, B. M., KISLYAKOV, V. B. and MASLENNIKOV, V. G., Physico-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] Pulse discharge of an underexpanded argon jet from a conical nozzle was studied in an experiment, with the 22° divergence angle designed for a flow velocity of $N_{Ma} = 4.0$ and with instruments based on an IAB-451 interferometer for measurements in a large shock tunnel. The stagnation parameters were determined from the velocity of an incident shock wave, the initial gas pressure and the pressure behind the reflected shock wave. Interferograms of the supersonic flow transient were interpreted by both the zone method and the method of least squares, the latter with some modifications. Radial density profiles indicate that the gas density increases downstream near the throat section of the nozzle and more uniform over the stream core farther from the throat, the core of the stream almost not changing while the width of the jet increases rapidly with a smooth decrease of density from the core toward the jet boundary. With the velocity of an incident shock wave equal to $N_{Ma} = 2.9$, the velocity at the nozzle throat varied from 3.75 to 3.9 within the core of the stream. Figures 2; references 5: 4 Russian, 1 Western.
[90-2415]

USSR UDC 534.12

THE AMPLITUDE STRUCTURE OF THE NEAR SONIC FIELD WITH INCLINED INCIDENCE OF A PLANE SONIC WAVE ON A CIRCULAR CYLINDER

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA - SERIYA 3 FIZIKA, ASTRONOMIYA in Russian Vol 20 No 4, Jul/Aug 79 pp 100-103 manuscript received 3 Mar 78

ARZHANOV, M. I., ROZHIN, F. V. and TONAKANOV, O. S., Department of Acoustics, Moscow State University

[Abstract] A study is made of inclined incidence of a plane sonic wave against an infinitely long cylinder with an acoustically soft boundary. Figures illustrate the distribution of amplitudes of pressure, radial and axial components of vibrational velocity as a function of distance r along

a straight line in the direction of the azimuth angle and perpendicular to the surface of the cylinder. Where $r = r_0 + 8\lambda$ for $kr_0 \leq 1$ the pressure of the scattered wave is 10% of the amplitude of the incident wave; where $kr_0 > 1$, this ratio is correct with greater values of $r > r_0 + 8\lambda$. Beyond the cylinder, at a distance of between r_0 and $r_0 + \lambda/4$, the amplitudes of pressure and velocity components of the scattered wave are small in comparison to the corresponding values of the incident wave, while at distances of around $r_0 + 8\lambda$, the distribution of pressure amplitude and velocity correspond to those of the incident wave even where $kr_0 = 8$. Figures 3; references 2 Russian.
[71-6508]

USSR UDC 532.517.4+534.526

TURBULENCE IN A "GRADIENT SUBLAYER" OF TWO-DIMENSIONAL DELAYED BOUNDARY LAYERS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 249 No 2, 1979 pp 298-302 manuscript received 16 May 79

KADER, B. A., Moscow Institute of Chemical Machine Building

[Abstract] A two-dimensional steady turbulent boundary layer of an incompressible fluid over a smooth wall is studied, which is at equilibrium in the sense that the turbulence in the cross section with x = const (x is read out in the direction of the flow) depends only on the density, kinematic viscosity, flow velocity, thickness of the boundary layer and kinematic gradient of longitudinal pressure. A study is made of the regularities of pulsation movement in the gradient sublayer. Although the experimental data are rather widely dispersed, they generally agree with the theoretical conclusion that the standardized values of moments are described by universal functions of the variable $Y = y\alpha/u_*^2$, approaching a constant value where $Y \ll 1$ and proportional to $Y^{1/2}$ where $Y \gg 1$. Figures 2; references 15: 4 Russian, 11 Western.
[63-6508]

USSR UDC 539.3:534.1

VIBRATIONS OF A VISCOELASTIC PLATE IN A SUPERSONIC FLOW OF GAS

Moscow IZVESTIYA AKADEMII NAUK SSSR, MEKHANIKA TVERDOGO TELA in Russian No 1, Jan/Feb 79 pp 184-188 manuscript received 25 Feb 77

ANVAROV, R. and GEGEL', E. I., Tashkent

[Abstract] Using the method of equivalent correspondence suggested in an earlier study (1975), a study is made here of the stability of induced vibrations of a viscoelastic plate in a plane supersonic gas stream. An analytical expression is arrived at for the critical velocity of the gas stream, taking into account the viscoelastic properties of the plate's material. The authors discuss small vibrations of a flat viscoelastic plate of infinite width, a thickness of 2h and a length of ℓ, moving in a straight line at a high supersonic velocity of U in a certain gas medium. Attack is not taken into account in motion of this plate in relation to the gas. An equation is derived for describing slight buckling of the plate on the assumption that the relationship between the stress and strain of the plate's material is in agreement with the linear theory of viscoelasticity and the forces of the aerodynamic effect are taken into account according to the piston theory. The case is discussed when the edges of the plate are hinged. A system of integrodifferential equations is obtained for vibration frequencies by employing the Bubnov-Galerkin method. A system of differential equations is derived from the system of integrodifferential equations in vector matrix form by the method of equivalent correspondence in a first approximation. A solution to this final system is studied for stability. The magnitude of a parameter dependent on the viscoelastic properties of the plate's material determines the critical value of the velocity of a viscoelastic plate Taking viscous drag into account results in lowering of the critical velocity of the plate as compared with the similar problem in an elastic formulation. References 10: 9 Russian, 1 Western.
[69-8331]

USSR UDC 621.378.325

FREE-ELECTRON LASERS

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 129 No 3, Nov 79 pp 541-547

KUZNETSOV, V. L.

[Abstract] A free-electron laser, or e-laser operates on the basis of the radiation of a relativistic electron flux moving in an external electromagnetic field. If the electron radiates while moving in a coherent field of an external signal, a new photon will very probably be emitted at the same frequency and in phase with the external stimulating field. This mechanism of amplification and generation of electromagnetic radiation has been experimentally demonstrated quite recently. Experiments at Stanford University have confirmed the theoretical ideas and served as a stimulus for further development in this area. Some of the advantages of e-lasers are noted: simple creation of an inverted population of energy states, easy frequency control by changing the energy of the electron flux and unlimited theoretical possible power of signal generated. A quantum interpretation of the problem of e-lasers is presented, along with means for optimization of e-laser systems using spherical mirrors. It is noted that all but one of the works in the literature on the subject assumed the presence of an external resonator. References 49: 12 Russian, 37 Western.
[73-6508]

USSR

EXTENSION OF THE OPERATING TIME OF A GAS-DYNAMIC PULSE LASER WITH A SHOCK TUBE

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 49 No 11, Nov 79
pp 2331-2337 manuscript received 19 Feb 79

TESTOV, V. G., GRIN', YU. I., MISHIN, G. I., PETROV, R. L., GRIGOR'YEV, V. V. and MENENKOV, V. D., Institute of Radio Engineering and Electronics, USSR Academy of Sciences, Moscow

[Abstract] A gas-dynamic laser with a shock tube is considered, and extension of the operating time during which the parameters of the working gas at the end of the low-pressure channel remain uniformly distributed so that the pattern of a collocated contact surface can develop. The optimum conditions under which this operating time will be maximum are established on

the basis of the fundamental relation for the operating time as a function of gas and channel parameters as well as the thermodynamic relations for a shock wave. This theoretical analysis is followed by an analysis of experimental data pertaining to two laser mixtures: 0.1 CO_2+ 0.1 N_2+ 0.8 He and 0.1 N_2O+ 0.2 N_2+ 0.7 He. Measured were the laser emission and amplification as well as the optimum tube length and the optimum operating time as functions of the partial nitrogen pressure in the propelling gas at the nozzle entrance, also the life of an active laser medium there. Measurements were made with the Mach number at the channel end remaining below its value corresponding to a collocated contact surface. The results indicate that it is feasible to extend the operating time in the collocated-contact-surface mode. Figures 5; references 18: 9 Russian, 9 Western.
[90-2415]

USSR UDC 621.378.33

DOUBLE SELF-MODE LOCKING IN A RUBY LASER

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 49 No 11, Nov 79 pp 2436-2438 manuscript received 19 Mar 79

VARNAVSKIY, O. P., KOLDASHOV, G. A., LEONTOVICH, A. M. and MOZHAROVSKIY, A. M., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Double self-mode locking in a ruby laser was studied experimentally, with an 80 cm long resonator cavity formed by two plane mirrors with reflection coefficients of 1.0 and 0.8 respectively. A lens with a focal length of 1500 cm was placed inside this cavity for compensating the thermal lens in the ruby and for producing an unstable resonator. A glycerin solution of cryptocyanide with a relaxation time of 75-100 ns served as a nonlinear saturating absorption filter with a 0.4 initial transmission coefficient. The resonator cavity of this filter, made half as long as the main resonator cavity, was formed by a plane mirror with a reflection coefficient of 0.75 and an opaque mirror with a radius of 150 cm. The axes of the two resonators were at a 30° angle to each other. A signal from the dye was found to have a period equal to half the period of a main emission signal and to lag 50 ns behind. A pulse train of radiation from the dye peaked 19 ns later than a pulse train of radiation from the ruby. With both resonator cavities equally long, emission from the dye was unstable. The feasibility of shortening the pulse duration under conditions of double self-locking was examined by a numerical solution of the balance equations of coupled emission from a ruby and a dye, a calculated 30% decrease agreeing

closely with experimental data, but no attempt was made to optimize the emission from the dye. The authors thank M. D. GALANIN for his interest and attention. Figures 2; references 9: 3 Russian, 6 Western.
[90-2415]

USSR UDC 621.378.325

LASER BREAKDOWN OF TRANSLUCENT POLYMERS WITH VARIOUS ATOMIC COMPOSITIONS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 49 No 11, Nov 79 pp 2496-2497 manuscript received 12 Apr 79

ALDOSHIN, M. I., GERASIMOV, B. G., MANENKOV, A. A., MASLYUKOV, A. P., NECHITAYLO, V. S. and PONOMARENKO, YE. P., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] A broad class of polymers with various atomic compositions and various viscoelastic characteristics (polymethyl methacrylate, polymethacryl ether of ethylene glycol, polystyrene, polybutyl methcrylate, and several copolymers of these or methyl methacrylate) was subjected to breakdown by laser irradiation. A multimodal ruby laser emitting giant 20 ns pulses with a smooth waveform and a uniform spatial distribution was used as the source. Bulk breakdown thresholds under single irradiation and laser resistance under repetitive irradiation were measured in terms of the number of pulses at a fixed prethreshold laser intensity that a specimen could absorb prior to visible microcracks. The results confirm the prediction that viscoelastic characteristics influence the laser resistance of not only aliphatic polymers but also of polymers containing aromatic fragments, a lower limit of stimulated elasticity corresponding to a higher laser resistance, while variations in the atomic composition do not significantly affect the laser resistance. Tables 1; references 1 Russian.
[90-2415]

USSR UDC 539.12

DISTRIBUTION OF THE FASTEST PARTONS AND HADRONS IN A HADRON STREAM

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 249 No 2, 1979 pp 341-345
manuscript received 3 Jul 79

BAYER, V. N. and GROZIN, A. G., Institute of Nuclear Physics, Siberian Division of USSR Academy of Sciences, Novosibirsk

[Abstract] The formation of a stream of hadrons upon interaction of high energy particles is one important prediction of the parton model. According to quantum chromodynamics, the distribution of hadrons carries an imprint of the initial parton distribution arising upon development of a parton shower in the case of large momentum transfers. In this work, a study is made of the distribution of the most rapid partons and hadrons in a jet within the framework of the principal logarithmic approximation of quantum chromodynamics. Results of modeling at 20 GeV are shown, based on 2,226 events. The quark jet arising upon e^-e^+ annihilation was studied. The current results are compared with the predictions of Field and Feynman. Figures 2; references 4: 1 Russian, 3 Western.
[63-6508]

USSR UDC 533.951

EFFECT OF THE INTRINSIC ELECTROMAGNETIC FIELDS OF HIGH-CURRENT ELECTRON BEAMS ON THEIR TRAJECTORIES

Tomsk IZV. VUZ: FIZIKA in Russian No 10, Oct 79 pp 27-46

DIDENKO, A. N. and RYABCHIKOV, A. I., Scientific Research Institute of Nuclear Physics, Tomsk Polytechnic Institute imeni S. M. Kirov

[Abstract] Methods of controlling the trajectories of relativistic high-current electron beams propagating through a neutral gas have been studied at the Scientific Research Institute of Nuclear Physics as well as in other laboratories. Reflection at surfaces of adjacent ferrodielectric media under conditions of charge and current neutralization provides an efficient mechanism, especially at low residual gas pressures, due to the role played by the intrinsic electromagnetic fields of such beams and the attendant self-focusing effect. Cherenkov radiation also plays a role, but a significant one only initially after beam injection into the gas and polarization of the dielectric wall. The intrinsic fields of such a beam also facilitate its propagation through transverse magnetic fields along plasma channels.

Methods of thus controlling the trajectories of relativistic high-current electron beams can be effectively used for formation of dense electron rings and for heating plasmas or targets to thermonuclear temperatures. They can also be used for more precise and undistorted measurements in experimental studies. Figures 5; references 36: 26 Russian, 10 Western.
[88-2415]

USSR UDC 533.951

RELATIVISTIC HIGH-CURRENT MICROWAVE PLASMA ELECTRONICS

Tomsk IZV. VUZ: FIZIKA in Russian No 10, Oct 79 pp 47-58

BOGDANKEVICH, L. S., RABINOVICH, M. S. and RUKHADZE, A. A., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] A survey is presented of achievements in relativistic microwave plasma electronics, particularly in devices operating with high-current electron beams. Included are Cherenkov oscillators (traveling-wave tubes, backward-wave tubes, magnetrons) and cyclotron generators (gyrotrons), based respectively on Cherenkov radiation and on magnetic bremsstrahlung of a free fast electron. Their performance characteristics are analyzed here from the standpoint of attainable beam currents, these characteristics being determined essentially by the dependence of power and efficiency on the gas pressure and the plasma density. Design and performance improvements are traced from the first Cherenkov oscillators (USSR 1973, USA 1974) and the first gyrotrons (USSR 1974, USA 1975). Figures 7; tables 2; references 21: 17 Russian, 4 Western.
[88-2415]

USSR UDC 533.951.2.3

ACCELERATION OF IONS IN RECTLINEAR HIGH-CURRENT ELECTRON BEAMS

Tomsk IZV. VUZ: FIZIKA in Russian No 10, Oct 79 pp 59-82

GAPANOVICH, V. G. and KOLOMENSKIY, A. A., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Results of research in the USSR and in the USA on acceleration of ions by high-current electron beams are reviewed, particularly those mechanisms and techniques which have recently reached a very high level of theoretical and experimental development. As an alternative to acceleration of ions by electron rings, much attention has been paid to their acceleration by injection of a high-current electron beam into a neutral gas under minimum pressure, and to consideration of the effects of pressure gradients and longitudinal magnetic fields as means of increasing that acceleration. Ions have also been accelerated in Luce vacuum diodes with a dielectric anode and, more recently, by high-current electron beams propagating through dielectric tubes. Other methods include the use of gaseous lenses displacing the beam crossover along its axis, acceleration of ions by scanning with the beam of an electron microscope or by uniform rotation of the electron beam, in each case the crossover being displaced transversely, also acceleration of ions by the quasi-static field of high-current electron beams and, finally, self-resonant acceleration of ions. Figures 6; references 85: 39 Russian, 46 Western.
[88-2415]

USSR UDC 533.951.2.3

HIGH-CURRENT-PULSE ION BEAMS

Tomsk IZV. VUZ: FIZIKA in Russian No 10, Oct 79 pp 83-105

BYSTRITSKIY, V. M., Scientific Research Institute of Nuclear Physics, Tomsk Polytechnic Institute imeni S. M. Kirov

[Abstract] High-current ion beams offer two advantages over high-current electron beams in controlled inertial thermonuclear fusion, namely high ionization losses with the released energy peaking toward the end of the beam path at the target and a nearly complete absence of bremsstrahlung with its adverse effect of preheating the fuel. High-current-pulse ion beams are now generated either by classical ring accelerator-accumulators

or by collective acceleration in a plasma (electron beams, clusters). Another method is their generation with modified diode guns of nanosecond high-current accelerators. In order to produce an efficient ion gun, it is necessary to suppress the electron component, and various methods of achieving this are based essentially on implications of the Childs-Langmuir law. Here several devices for this purpose are described, namely a triode and a twin diode where multiple reflections of electrons occur, a magnetic-isolation diode where electrons are cut off, and a pinch-effect diode where a radially focused electron beam forms with an axial ion beam in the interelectrode gap of a smoothly adjustable width. Design and performance data on the VERA and the TONUS ion beam generators at the Tomsk Polytechnic Institute are compared with those characterizing several in the United States (Cornell University, National Research Laboratories, SANDIA). Figures 8; tables 1; references 91: 13 Russian, 78 Western.
[88-2415]

USSR UDC 535.231.12

CHERENKOV RADIATION OF MONOCHROMATIC BEAMS OF PARTICLES CONSIDERING THEIR INTERACTION

Moscow VESTNIK MOSCOVSKOGO UNIVERSITETA SERIYA 3 FIZIKA - ASTRONOMIYA in Russian Vol 20 No 5, Sep/Oct 79 pp 71-74 manuscript received 16 Jun 78

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[Abstract] The purpose of this work is to derive and qualitatively analyze equations for the intensity of Cherenkov radiation of a beam of particles moving in a fixed direction (with negligible divergence), low dispersion of speeds and initial coordinates. This statement of the problem is of interest due to the possibility of constructing a model of an experiment for detection of interference effects and studying parameters of beams of charged particles. References 4: 2 Russian, 2 Western.
[70-6508]

USSR UDC 537.56

NUCLEAR RELAXATION OF He^3 ATOMS IN A GAS DISCHARGE AT LIQUID-NITROGEN TEMPERATURE

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 49 No 11, Nov 79 pp 2462-2465 manuscript received 12 Jan 79

KARTOSHKIN, V. A., Physico-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] Relaxation of He^3 nuclei in a mixture of $He^3 + He^4$ isotopes at a temperature of 77 K was studied experimentally in an absorption chamber under a pressure below 1 torr. The relaxation time for nuclear spins was determined from measurements of the transient process following application of an r-f magnetic field at resonance with the 2^3S_1 state. A new equilibrium orientation of half-levels of the metastable helium state will occur after one of three characteristic time periods, the reciprocal of each equal to the reciprocal of the nuclear relaxation time minus a correction term. The results yield a dependence of the He^3 nuclear relaxation time t on the concentration of metastable helium atoms n which can be approximated by the relation $t \sim n^{-1.5}$. This trend is attributable to resonant He^+ ion charge exchange on helium atoms in the ground state, the main relaxation process at low pressures. The contribution of He_3^+ atoms becomes significant at high pressures. The author thanks R. A. ZHITINKOV for his attention. Figures 2; references 5: 1 Russian, 4 Western.
[90-2415]

USSR UDC 535.51

RECONSTRUCTION OF THE DEGREE OF POLARIZATION OF A WAVE FIELD BY POLARIZATION HOLOGRAPHY

Tbilisi SOOBSHCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian Vol 96 No 1, 1979 pp 73-76 manuscript received 27 Jul 79

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[Abstract] Electromagnetic waves are almost always partly polarized due to scattering and reflection of radiation, fluctuation effects in radiating systems and so forth. Partly polarized radiation can be resolved in the form of two components with mutual orthogonal polarization and mutual complete incoherence, and with maximum difference in intensities. The measure of partial polarization is defined as $V = (I_{max}-I_{min})/(I_{max}+I_{min})$, where I_{max} and I_{min} are the intensities of the maximum and minimum components. The authors solve the problem of reconstruction of this parameter by polarization holography. It is found that a necessary condition for solving the problem is the use of photoanisotropic media as the holographic material, and a reference wave that is completely unpolarized. Experiments in polarization recording were done in both transmitted and reflected light. The results show that reconstruction of the degree of polarization is possible in both the Gabor and Denisyuk methods. References 8: 7 Russian, 1 Western. [84-6610]

USSR UDC 538.566:621.372.413

EXPERIMENTAL STUDY OF THE CHARACTERISTICS OF THE DIFFRACTION YIELD OF AN UNSTABLE QUASIOPTICAL RESONATOR

Moscow VESTNIK MOSCOVSKOGO UNIVERSITETA SERIYA 3 FIZIKA - ASTRONIMIYA in Russian Vol 20 No 5, Sep/Oct 79 pp 91-93 manuscript received 4 May 78

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[Abstract] Measurements of the output characteristics of an unstable resonator were performed at a wavelength of 7.2 mm. The diffraction picture beyond the output mirror of the resonator was visualized by movement of the receiver in the horizontal plane perpendicular to the axis of the resonator. An equation is presented for the distribution of the field near the output

mirror, which describes Fraunhofer diffraction on a circular aperture and agrees well with the experimental data. The equation can be used to estimate the degree of concentration of energy in the central portion of the output beam. Figures 3; references 7: 6 Russian, 1 Western.
[70-6508]

USSR UDC 533.951.7

SOME PROBLEMS OF THE QUASILINEAR PLASMA THEORY

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA - SERIYA 3 FIZIKA, ASTRONIMIYA in Russian Vol 20 No 4, Jul/Aug 79 pp 22-28 manuscript received 14 Mar 78

KUZ'MENKOV, L. S. and POLYAKOV, P. A., Department of Theoretical Physics, Moscow State University

[Abstract] A study is made of the quasilinear plasma theory considering radiation effects. Consideration of the resulting nonlinear terms in the equations describing the plasma causes the mean equilibrium distribution to be time dependent and results in the appearance of interaction between waves, greatly complicating the theoretical analysis of plasma phenomenon. However, in a collisionless plasma, radiation attenuation in many practically important cases is more important than Landau attenuation. The relativistic kinetic equation of Vlasov is analyzed considering radiation deceleration of particles. Consideration of radiation effects results in changes in the distribution function of particles of the plasma both when Langmuir waves propagate through the plasma and when electromagnetic waves propagate through it. The full energy of the particles of the plasma for propagation of Langmuir waves is not retained due to radiation deceleration. When electromagnetic waves propagate through the plasma, the increase in mean momentum and energy of particles results from a decrease in the momentum and energy of waves. Figures 2; references 8: 7 Russian, 1 Western. [71-6508]

USSR UDC 621.791.052.539.43

STUDY OF THE INFLUENCE OF THE SHAPE OF THE WELD AND OF THE STRAIN INHOMOGENEITY OF WELDED BUTT JOINTS ON MECHANICAL ENDURANCE

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR, MEKHANIKA in Russian Vol 32 No 4, 1979 pp 56-62 manuscript received 17 Jan 79

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[Abstract] A determination is made of the theoretical value of the critical angle and of the influence of the shape of the groove of a welded butt joint on mechanical endurance as a function of the strain inhomogeneity of the weld zone. The starting point for analysis is an equation for determining the critical combination, in terms of a low degree of stress on the edge of the contact surface, of values of angles between flat elements of the contact surface in the vicinity of its edge and the outer surface of the joint, for the general case of stressing a jointed body. This equation is simplified for the case of a machined smooth edge on the contact surface. It is shown that for a smooth edge by means of elementary computations it is possible to determine the critical (upper-limit) angle for the material with the lower elastic modulus. The material of the weld in a welded joint is as a rule highly inhomogeneous in terms of both chemical composition and mechanical properties, including strain properties, and thermal effects during welding can substantially alter the strength properties and almost have no influence on the strain properties of the material of the heat-affected zone. By knowing the strain properties of the weld material and of the base material it is possible to calculate the groove angles of a welded joint so that the conditions for a low stressed state can be fulfilled along the entire edge of the fused surface. The results are given of experiments in which grade 20 steel samples from the same melt were welded with a general-purpose ANO-6 electrode of the E42-t type with an ilmenite covering. A determination was made of the elastic constants of the weld metal on welded butt joint specimens measuring 3 X 5 X 40 mm. The mean value of the elastic modulus of the fused metal was 1.8 X 10^6 kg/cm^2 with a Poisson's ratio of 0.29. The mean value of the elastic modulus of the base metal was 2.12 X 10^6 kg/cm^2 with a Poisson's ratio of 0.32, and elastic constants were determined by tensile testing specimens cut from rolled sheets. Shear moduli are calculated for the weld metal and the base metal and it is found that the shear modulus of the weld metal, in terms of which the critical angle is calculated, is lower than that of the base metal. The critical angle is found to equal in this case $\leq$ 59°30', i.e., in this case the edge of the surface of contact will be in a low state of stress. Results are given of experiments conducted for the sake of comparing the endurance of a V-type weld with a backup weld and without one. Fatigue tests were conducted on grade 20 steel with a maximum stress of 12.5 kg/m^2 and a minimum stress of 2.5 kg/m^2, and it was found that under these conditions the endurance of

a V-type weld without a backup weld is 1.5-fold lower than that of a V-type weld with backup. The employment of a V-type weld with a backup weld equalizes the angles in the upper and lower halves of the joined materials and thus removes the concentration of stresses in these areas. Fatigue tests were conducted with a TsDM PU-10 push-pull fatigue testing machine at a rate of 100 cycles/min. Figures 3; references 5: 4 Russian, 1 Western. [68-8831]

USSR UDC 539.385

SHELL OF REVOLUTION OF MAXIMUM TORSIONAL RIGIDITY

Moscow IZVESTIYA AKADEMII NAUK SSSR, MEKHANIKA TVERDOGO TELA in Russian No 1, Jan/Feb 79 pp 138-144 manuscript received 16 Jun 77

GURA, N. M., Moscow

[Abstract] The problem is studied of finding the optimal design of a shell of revolution having maximum torsional rigidity with a predetermined volume of the shell. Several variants of this problem are discussed, employing as control functions, in conjunction or separately, the form of the meridian of the middle of the surface and the distribution of thickness along the meridian. The influence of torque on the thickness of the shell is discussed in particular. The equation of equilibrium is written and boundary conditions are set for two variants: when the shell of revolution is fastened at both edges and when one edge is free and the other is fastened. The optimization problem consists in finding functions h(z) or R(z) or h(z) and R(z) together which will satisfy the isoperimetric condition, based on the assumption of a predetermined volume and known radii of the shell's edges, such that a minimum is realized for a functional describing the displacement. Here h is the thickness of the shell, R is the radial torque, and z is the z-axis of the shell. For the case of a shell of revolution with a free edge a determination is made of the optimal distribution of thickness, h(z), and of the form of the meridian of the middle of the surface, R(z). A determination is made of the optimal design of a shell of revolution for the case when function h(z) serves as the control function and function R(z) is assigned. The optimal distribution of thickness is found for a conical shell. In order to take into account the influence of torque on the optimal distribution of thickness, numerical methods of solving the optimality condition are used. Also discussed is the problem when the form of the meridian of the center of the shell's surface serves as the control function and the thickness of the shell is an assigned function. It is demonstrated analytically that if there is sufficient material, then the form of the meridian tends to depart as much as possible from the axis of

revolution. If there is too little material, then the form of the meridian tends toward a catenary, i.e., to a shell of minimal surface. The case is also considered when both the thickness of the shell and the form of the meridian of the center of the surface are control functions. Here, too, the form of the meridian of the surface's center depends on the area of the surface: For an optimal torque-free shell it is better to use more material to reduce the torsional force than to economize on material and reduce the surface of the shell, thereby increasing the torsional force. The necessary condition of optimality is derived which the thickness of the shell must satisfy for the case when both edges of the shell are closed and function R(z) is known. Figures 5; references 5: 3 Russian, 2 Western.
[69-8831]

USSR UDC 539.3:534.1

INITIAL POSTCRITICAL BEHAVIOR OF CYLINDRICAL SHELLS UNDER EXTERNAL PRESSURE

Moscow IZVESTIYA AKADEMII NAUK SSSR, MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan/Feb 79 pp 155-162 manuscript received 24 Nov 77

BADENKO, V. I., Khar'kov

[Abstract] Based on the results of high-speed motion picture photography of the process of the loss of stability, i.e., buckling, of a cylindrical shell, a method is suggested for deriving asymptotic equations for the critical load and forms of equilibrium at the initial postcritical stage of developable shells under external pressure. A study is made of the loss of stability in a closed cylindrical shell with a strictly convex cross section, assuming that the shell is fairly thin, of moderate length, linearly elastic and hinged along the edge. The method used here considers the problem of determining the critical load and of describing the periodic structure of postcritical strains in cylindrical shells independent of one another and unrelated. It is suggested that the form of equilibrium at the initial postcritical stage of a developable shell under external pressure differs considerably from the subcritical, or close to zero-moment stage, only in the narrow vicinity of a certain generating line, γ, of the center of the surface, F, of the shell. Buckling begins with the formation of a single dent stretching along γ. The theoretical discussion begins with nonlinear equations of the theory of the "average buckling" of flat shells in dimensionless form. An asymptotic solution is found to this system of equations, in terms of the minor parameter of a relatively thin-walled state. A vector function, U, is introduced, and in each of the regions of $F_{1\beta}$, representing two subregions of two regions into which F is divided,

an asymptotic form is constructed for U in the form of a series in terms of the square root of the relative wall thickness parameter. One term of this series, U_{11}^{0}, is determined from solution of the boundary value problem, and a trivial solution to this problem describes subcritical strains. Post-critical strains are in accord with nontrivial solutions to the boundary value problem. An asymptotic form is found for a nontrivial solution to the system of equations describing the boundary problem. The resultant pressure dependence of maximum buckling agrees qualitatively with the conclusions of an earlier theory (1968). References 4: 3 Russian, 1 Western.
[69-8831]

USSR UDC 539.3

THE STRESSED STATE OF UNEVENLY HEATED PLATES LOADED ON THE BOUNDING SURFACES

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 43 No 6, Nov/Dec 79 pp 1065-1072 manuscript received 26 Jun 78

MAKSIMOVICH, V. N., L'vov

[Abstract] The stresses $\tau_{zx} = \tau_{zy} = 0$, $\sigma_{zz} = \sigma_{\pm}$, $z = \pm h$ are assigned on the boundary planes of a uniformly heated layer of thickness 2h. The symmetric and antisymmetric problems are solved separately: 1) at constant temperature under given conditions on the bounding planes; 2) with given nonuniform heating and zero stresses. Simple formulas are given for determining the stressed state in the case of slowly varying external loading and temperature of an infinite plate. References 10 Russian.
[80-6610]

USSR UDC 531.383

CERTAIN CASES OF INSTABILITY OF A DIRECTIONAL GYROSCOPE

Moscow IZVESTIYA AKADEMII NAUK SSSR, MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan/Feb 79 pp 5-10 manuscript received 4 Jan 78

AGAFONOV, S. A., Moscow

[Abstract] A theoretical study is made of the stability of the precessional motion of a directional gyro for the case when the point of suspension of the gyrosphere moves along a parallel at a steady speed. Equations for the precessional motion of the system are given for these conditions and the case is considered when $0 < \mu \leq 1$, where $\mu = v^2/gR$, where v is the absolute velocity of the point of the suspension, g is the acceleration of the force of gravity and R is the radius of the earth. The motion equations also take into account the mass of the entire system, the distance from the center of mass of the system to the point of the suspension, the angular momentum of the gyroscopes, the angular velocity of diurnal rotation of the globe, the latitude of the object's position, the easterly component of the velocity of the point of the suspension, and angles defining the position of the gyrosphere in relation to the geographical system of coordinates. An investigation is made of the cases when internal resonance of the third order exists between frequencies of the linear system and when one of the frequencies equals zero. A particular solution is given for the system of equations of precessional motion, and the sufficient condition for the stability of this solution, derived from the condition for positive definiteness of the integral of the equations for perturbed motion, is $\omega^2 < \nu^2 (1 - \nu)$, where $\nu^2 = g/R$. The case of internal resonance of the third order is that in which $\omega_1 = 2\omega_2$. It is demonstrated that internal resonance of the third order results in instability. Cases of $\omega = \nu(1 - \mu)^{1/2}$ and $\omega = \nu$ are discussed. It is demonstrated for the case when one of the frequencies equals zero that instability is proven by means of plotting a Chetayev function (Chetayev, N. G., "Ustoychivost' dvizheniya" [Stability of Motion], Moscow, Nauka, 1965), in the form of $V = \kappa y_1 y_2 - y_1$, where $\kappa > 0$ is a certain constant and the region of $V > 0$ is defined by the inequalities $y_1 < 0$ and $y_2 < 0$. Instability is demonstrated by means of the functions $V = \kappa y_1 y_2 + y_1$ and $V = y_1 y_2 - y_2$, respectively, for the cases of $\omega = -\nu\sqrt{1 - \omega}$ and $\omega = -\nu$. The frequencies referred to, ω and ν, are found in the characteristic equation for the linear half of the system of equations for perturbed motion, which in turn are derived from equations for the precessional motion of a directional gyro when the point of the suspension of the gyrosphere moves along a parallel at a constant velocity. References 8 Russian.
[69-8831]

USSR UDC 531.55:521.1

ORIENTATION OF A SATELLITE IN A PREDETERMINED DIRECTION

Moscow IZVESTIYA AKADEMII NAUK SSSR, MEKHANIKA TVERDOGO TELA in Russian No 1, Jan/Feb 79 pp 11-18 manuscript received 19 Apr 76

SAAKYAN, L. S., Yerevan

[Abstract] A method is given for plotting control moments applied to a satellite whose center of mass describes a circular orbit in a Newtonian field of forces for the restricted case when the influence that motion around the center of mass has on the motion of the center of mass is disregarded. The solution of the problem of orienting the satellite in a predetermined direction, α, is found by finding a control moment, M, which when applied to the satellite combines vector n, which is a basis vector whose position remains unchanged in the moving system of coordinates $Ox_1x_2x_3$, with vector α and stabilizes this direction. The inertial system of coordinates, $O_1\xi\eta\zeta$, has as its origin the center of gravity, O_1, and the origin of the moving system of coordinates, $Ox_1x_2x_3$, is the satellite's center of mass, O, with axes pointing along the main central axis of inertia. An orbital system of coordinates, Oxyz, is introduced, with the z axis pointed along straight line OO_1, axis x in the direction of movement of the center of mass along the straight line orthogonal to axis z and located in the plane of orbit, and axis y complementing axes x and z to form a right trihedron. Representing the basis vectors of axes z and y are α and β, respectively. The case is considered of two orthogonal basis vectors, n and m, rigidly linked to the satellite. It is assumed that in moving system of coordinates $Ox_1x_2x_3$ are measured only the projections of vectors α, β and β'. The problem is solved of, employing the projections of vectors α, β and $\beta\cdot$, plotting a control moment, M, which will stabilize predetermined senses of n and m in relation to the senses of the radius vector to the normal of the circular orbit. Also considered is the case of a gyrostat-type satellite in which along the main axes of inertia of the satellite are placed the axes of three similar symmetric flywheels which are rotated by special motors. Given are two orthogonal basis vectors, n and m, rigidly linked to the gyrostat-type satellite. The problem is solved of applying to the flywheel a control moment, M, making it possible to stabilize basis vector n in the direction of the radius vector of the circular orbit, and basis vector m in the direction of the normal to the plane of the stationary orbit. The need for employing special instruments to measure various of the magnitudes discussed theoretically is stressed. Conditions are found whereby with the application of control moment M applied to the flywheels so that the satellite is oriented in assigned directions α and β, any movement of the gyrostat-type satellite is either a position of relative equilibrium or asymptotically approaches this position. Figure 1; references 7 Russion.
[69-8831]

USSR UDC 531.383

EMPLOYMENT OF METHODS OF IDENTIFICATION FOR ESTIMATING ERRORS OF DOUBLE-ROTOR GYROCOMPASSES ON A ROCKING BASE

Moscow IZVESTIYA AKADEMII NAUK SSSR, MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan/Feb 79 pp 27-31 manuscript received 10 Jan 78

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[Abstract] Errors differing by two to three orders of magnitude from the actual values are obtained when calculating errors of double-rotor gyrocompasses with rocking, by employing the precession theory without taking into account the elastic compliance of structural elements and their inertia, the flow of fluids and possible free play in the pivots of the gyroscope's suspension. It is possible to take into account these factors by employing a mathematical model of a gyroscope system based on experimental data with consideration of the joint effect of both known and unknown factors causing an error in the gyroscope system. Examples are given of the application of the method of identification for constructing a mathematical model from the input and output variables of a system when it is functioning. The employment of methods of identification makes it possible to arrive at a more adequate model of a system which takes into account both the theoretical and certain structural features of the gyroscope system. It also makes it possible more accurately to predict its output coordinate under the effect of disturbances. Experimental methods of constructing models are based on the assumption that the parameters of the object are lumped, that the dynamic properties are stable over time and that they are linear with slight variations in input coordinates. A model is constructed by selecting a structure for the model from physical considerations, determining the criteria for comparing modeled and experimental characteristics, which criteria depend on the requirements for the precision of modeling and on the amount and completeness of experimental data, by matching the parameters of the model with the available experimental data (estimating), by testing and confirming the adequacy of the model over all ranges of possible external disturbances, and by using the model for its purpose. Equations are obtained for computing the intercardinal errors of a gyrocompass in regular and irregular rocking. One system of equations based on the laws of mechanics and another system based on methods of identification by employing experimental data on the errors of a gyrocompass is employed to compute the errors resulting from rocking. There is good agreement between the calculated and experimental results. The mathematical model arrived at for a gyrocompass can be used for investigating the influence of rocking and maneuvering of a ship for the entire range of instruments employing a device of this sort. References 12 Russian.
[69-8831]

USSR UDC 531.383

THEORY OF A GYROSCOPE ON A ROTATING CARDAN SUSPENSION

Moscow IZVESTIYA AKADEMII NAUK SSSR, MEKHANIKA TVERDOGO TELA in Russian
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TERESHIN, V. G., Ufa

[Abstract] An analysis is made of the capabilities of a gyroscope on a rotating Cardan suspension for determining the parameters of angular motion of a base. It is demonstrated that a gyroscope of this sort can be used as a vibration-sensing device for slowly varying angular velocities. A discussion is given of the dynamics of a gyroscope with forced uniform rotation of the Cardan suspension. The assumption is made that the suspension's structure employs elastic elements having infinitely high flexural rigidity and finite torsional rigidity. Linked to the base is a system of axes $O\xi_1\eta_1\zeta_1$ whose position relative to inertial system of coordinates $O\xi\eta\zeta$ is defined by angles Θ and Ψ. The position of the gyroscope's main axis, Oz, is determined by the angles α and β read from axes $O\xi_2\eta_2\zeta_2$ linked to an auxiliary ring which rotates at a constant angular velocity of ω around axis $O\zeta_1$. The angular rotational velocity of the ring, Ω, is an order of magnitude higher than velocities Θ^* and Ψ^*. Linearized differential equations are given, describing the motion of a gyroscope on a rotating Cardan suspension on a fixed base. The useful signal bearing information on Θ^* and Ψ^* consists of the amplitude and phase of the envelope of angular vibrations of the gyroscope's rings taking place at the frequency of forced rotation of the auxiliary ring. These angular vibrations depend on both measured velocities Θ^* and Ψ^* simultaneously. Consideration of the law of motion of a gyroscope for the case of separating a signal in a non-rotating system of coordinates shows that the useful signals are the amplitude and phase of the envelope of angular vibrations taking place at double the frequency of the forced rotation, and also the steady deflections of the gyroscope's main axis. These steady deflections depend on angular velocity Θ^* for one angle and on angular velocity Ψ^* for another angle. A gyroscope on a rotating Cardan suspension represents a generalized dynamic model of vibration-sensing detectors of the parameters of angular movement of the base. Slowly varying angular velocities Θ^* and Ψ^* can be measured simultaneously regardless of which gimbal's angle of turn the signal is derived from and in which system of coordinates. Figures 1; references 5: 4 Russian, 1 Western.
[69-8831]

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CALCULATION OF NONLINEAR PARAMETRIC VIBRATIONS OF CYLINDRICAL SHELLS

Moscow IZVESTIYA AKADEMII NAUK SSSR, MEKHANIKA TVERDOGO TELA in Russian
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BOGDANOVICH, A. YE. and FELDMANE, E. G., Riga

[Abstract] A procedure is established for selecting the required number and kind of basis functions approximating the buckling of a shell with nonlinear parametric vibrations. In expanding buckling in terms of forms of natural vibrations, it is necessary to take into account only the harmonics in the region of dynamic instability that contains specific values of the amplitude and frequency of the external load. It was found in earlier studies that when the amplitude and frequency of the influencing load fall within the region of instability in the parameter plane the amplitude of the buckling increases exponentially with time, and if the parameters fall within the region of stability, buckling of the construction is on the order of magnitude of original imperfections. The position and form of regions of dynamic instability are determined totally from solving the linear problem of parametric vibrations and the various nonlinear factors at work under real conditions of use of a construction result in limitation of buckling over time even within regions of dynamic instability. A closed, round, mildly sloping isotropic cylindrical shell loaded with an axial force of the $P = (P_0 + P_t \cos\theta_t)/(2\pi R)$ type, where R is the radius of the center of the shell's surface, is discussed for the purpose of illustrating the method of selecting functions approximating buckling with nonlinear parametric vibrations. Two known equations for average buckling describe the reaction of the shell with mild strains but finite displacements, disregarding tangential components of the reduced load and inertial terms. An expression is derived for the stress function from the first of these equations. By substituting this expression and a certain approximation for buckling in the equilibrium equation and applying the Bubnov-Galerkin procedure, a system of ordinary differential equations is arrived at. It is demonstrated that in solving the problem of nonlinear parametric vibrations the choice of the buckling approximation must be determined on the basis of the nature of the position of regions of dynamic instability of the design under consideration. It is demonstrated that it is necessary to calculate the entire range of regions of dynamic instability for all possible forms which can be realized in the frequency range of interest. The case is discussed when a point on the plane of parameters corresponding to a specific load amplitude and frequency lies in the intersection of two regions for certain forms. In the particular case discussed, vibrations for both forms are of a beat frequency nature. Buckling at a certain point on the shell represents the superposition of two beat frequencies. These two beat frequencies occur for different circular forms of wave formation and their superposition creates a complex pattern

of vibrations in the diametric cross section of the shell. By solving the nonlinear system of two equations for average buckling by employing the Bubnov-Galerkin method, it is possible to expand the buckling in a double Fourier series in terms of the longitudinal and circumferential coordinates of the shell. By solving the corresponding linear problem and knowing from this the diagrams of regions of dynamic instability, it is possible to establish what terms in these expansions must be taken into account with a specific combination of the amplitude and frequency of the external load. Figures 3; references 13: 9 Russian, 4 Western.
[69-8831]

USSR UDC 519.3

CONCERNING A GENERALIZATION OF A THEOREM FROM THE THEORY OF OPTIMUM STABILIZATION

Ashkhabad IZVESTIYA AKADEMII NAUK TURKMENSKOY SSR: SERIYA FIZIKO-TEKHNICHESKIKH, KHIMICHESKIKH I GEOLOGICHESKIKH NAUK in Russian No 1, 1979 pp 3-8 manuscript received 14 Dec 77

RAKHIMOV, M., Turkmen State University imeni A. M. Gor'kiy

[Abstract] The author considers the problem of optimum stabilization of distributed systems where the process is described by hyperbolic and parabolic equations. The method of finding the optimum control proposed by A. I. Yegorov ("Optimum Stabilization of Systems with Distributed Parameters. Abstracts of Papers of the International Technical Conference. IFIP optimizatsii," Novosibirsk, 1974) gives specific recommendations for studying a number of questions of optimization of systems with distributed parameters. An examination is made of one of the generalizations of a theorem proposed by Yegorov for a parabolic system. References 6 Russian.
[74-6610]

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